Innovation Policy in Emerging Domains of Activity: First-Mover Advantage or Curse?

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Abstract- **Do first-mover advantages exist for public policy? The theory of the first-mover advantage has been well studied in organization theory and marketing science. It is generally accepted that first-mover firms have multiple benefits such as technological leadership, asset preemption, and heightened buyer switching costs [1,2]. First-mover firms also have the disadvantages of free-ridership, technology uncertainty resolution, enabling new entrants, and incumbent inertia [1,2]. Previous work has focused on the application of the first-mover theory to firms. However, much can be learned by applying first-mover advantage theory to other areas. Specifically, this study applies the arguments of first-movers to the development of innovation policy in nanotechnology. In addition to the insights provided by this application, additional conditions must be considered when examining the order of entry in innovation policy. The article concludes with a discussion of what follower policies can learn from first-movers. The maximization of later-stage advantages is also discussed.**

I. INTRODUCTION

Innovation policy is made up of economic, science, and technology focused initiatives designed to support the scientific discovery and commercial application of inventions [3]. As the goal of policy is to maximize the social collective benefits [4], the objectives of innovation policy are heightened innovative output often measured in terms of patents, publications, or products. Typically, innovation policies focus on one type of technology to facilitate its use in the economy and society. Billions of dollars spent each year on innovation policy in the U.S. alone. Thus, understanding optimal innovation policy has wide-ranging implications.

Work examining innovation policy is spans several discipline including economics, political science, business and management, sociology, and psychology, or what Morlacchi and Martin [5] call "a somewhat heterogeneous set of activities undertaken by a community of diverse actors." Recently, interest in R&D and innovation policy has surged [6] focusing on the outcomes of such policies and initiatives. For example, work has shown that innovation policy influences knowledge spillovers [7], entrepreneurship [3], industrial emergence [8], and economic growth [6].

Overall, work has shown that the outcomes of innovation policy are generally positive. However, little work has explored the dynamics or conditions necessary for optimal outcomes and efficacy. For example, a strong understanding of the role of timing and entry in innovation policy for nascent science and technology is lacking. An improved understanding of the dynamics between time and policy implementation efficacy has huge economic ramifications, particularly for regional, state, and local initiatives created to establish a competitive advantage for their areas.

The objective of this paper is to examine innovation policy timing of by extending insights from the first-mover advantage perspective as it informs innovation policy. First-mover advantages (and disadvantages) are mechanisms that confer above average benefits (or challenges) to those firms that enter the market earliest. First-mover advantages include technological leadership, scarce asset preemption, and heightened buyer switching costs. First-mover disadvantages include free-ridership, technology uncertainty resolution, enabling new entrants, and incumbent inertia. These advantages and disadvantages are not limited to firms alone, but can also be applied to other levels of analysis such as institutions, social movements and collective action, and policy. The following examines the insights that can be gained by applying the first-mover perspective to innovation policy.

This paper is intended to stimulate interdisciplinary debate on the role of timing in innovation policy. The paper proceeds as follows. The first section discusses innovation policy and our current state of knowledge. The second section discusses the first-mover perspective as it is traditionally applied to firms. The third section applies the first-mover perspective to innovation policy. I finish with a discussion of the practical implications of this research.

II. THEORETICAL FRAMEWORK

A. Innovation Policy

Innovation policy is wide-ranging to include science, technology, and research and development policy. For

instance, the United States R&D budget for 2010 is almost $150 billion (down from a jump to $165.4 billion in 2009 due to the Recovery Act). This funding is distributed mainly to the NIH, NSF, DOD, DOE, NASA, USDA, and others government agencies[1]. As areas of funding range from basic scientific research and education to national security and international affairs, innovation policy touches the lives of all citizens within its domain.

As a problem-oriented field [5], work in the area tends to focus on assessing the achievement of policy goals or the development of statistics and instruments for the measurement of these goals. A variety of measures are used to assess the product of science and technology such as R&D expenditures, patents and their citation rates, publications and their citations, firms, products, and employment statistics. While it is often taken for granted that innovation policy has positive outcomes, work has empirically examined its influence on both micro and macro levels. For instance, work has shown that innovation policy can increase the amount of knowledge spillovers [7], the speed and level of industrial emergence [8], and rate of economic growth [6].

The importance of the topic requires a more nuanced understanding of policy dynamics. In particular, policy makers chose when to create and implement initiatives. The timing of policy influences the type of outcomes that are possible. For example, Woolley and Rottner [3] show that states with the first innovation policies supporting nanotechnology also had higher rates of nanotechnology related entrepreneurship.

B. First-Mover Advantage

First-mover firms are those that enter the market earlier than other firms and constitute a pioneer in the field [1]. Lieberman and Montgomery proposed the idea of first-mover advantages in 1988 as "the ability of pioneering firms to earn positive economic profits" [1]. They argue that first-movers can gain advantage through technological leadership, scarce asset preemption, and heightened buyer switching costs. These mechanisms, along with a dose of luck and firm proficiency, enable the firm to generate profits beyond the cost of capital.

The first-mover advantage of technological leadership stems from early gains in learning and establishing patents or trade secrets. These mechanisms facilitate the diffusion of the first-mover's technology and can support higher adoption. Patenting or establishing trade secrets can allow a firm to move on early innovations to gain returns and challenging new entry into the market.

Scarce asset preemption is an advantage for firms when they are able to gain from controlling existing, rather than newly generated, assets. This allows a firm to prevent other firms from entering or positioning themselves similarly. Examples of scarce assets include input factors, location, plants, and equipment. Recently, scarce asset work has extended to complementary assets which are the resources that a firm needs to successfully market a new product or innovation such as distribution, after sales support, and competitive manufacturing [9]. However, not all complementary assets are the same. General complementary assets are not specific to the product and can be acquired outside the firm. On the other hand, specialized and co-specialized assets are idiosyncratic to the technology and product, making them difficult to procure. When a technology is nascent, this access can buffer existing firms from the threat of new entrants lacking such [10, 11]. Thus, after a technological discontinuity, first-mover firms benefit by acquiring specialized complementary assets that are costly to replicate.

First-mover firms can also gain by heightened buyer switching costs after their product has been adopted. New transaction costs, product and technology adaptation, learning, and contractual obligations are switching costs that can enhance the first-mover's market share [1, 2]. Taken together, these first-mover advantages are a formidable lead for early entrants.

However, first-movers are also susceptible to four types of disadvantages: free-ridership, technology uncertainty resolution, enabling new entrants, and incumbent inertia. Free-ridership takes the form of later entrants gaining from the work already done by the first-movers such as R&D, educating buyers, and developing infrastructure. This reduces the sustainability of the first-mover's competitive advantage and erodes early gains.

The resolution of technology uncertainty is a disadvantage for first-movers in that while they can influence the early direction of a nascent technology's development, their efforts may be expensive and resource draining. Thus, later entrants can benefit from this effort by starting work on the technology once its trajectory has been determined. The third first-mover disadvantage is related in that the evolution of the technology or customer needs may provide opportunities for new entrants to exploit underserved niches or technological discontinuities.

Lastly, first-movers are susceptible to what is known as "incumbent inertia" or the internal and external pressures which limit the firm's ability to adapt [12]. Incumbent inertia provides an opportunity for new entrants with more flexibility and adaptability to enter the market and exploit incumbent weaknesses.

III. INTEGRATING FIRST-MOVER THEORY AND INNOVATION POLICY

First, we can apply the first-mover theory to innovation policy to define first-mover innovation policy as a pioneering public policy initiative that addresses a nascent

[1] From the Office of Science and Technology Policy's website: www.ostp.gov/galleries/budget/FY2010RD.pdf accessed July 25, 2009. NIH is the National Institute of Health, NSF is the National Science Foundation, DOD is the Department of Defense, DOE is the Department of Energy, NASA is the National Aeronautics and Space Administration, and the USDA is the United States Department of Agriculture.

science, technology, and innovation area before others. First-mover innovation policies are those initiatives in support of science, technology, and research and development that occur during the creation or emergence of a technological breakthrough. These policies are the forerunners to support cutting-edge technologies at their earliest. During the emergence of nascent technologies, uncertainty abounds making it important for the early innovation policies to have a broad focus. Later-stage innovation policies follow on a technology that has been developed or is in maturity. These are appropriate for the incremental development tor technological extensions. Resources are more focused and the objectives of later-stage initiatives are narrower. Later-stage initiatives are not in the same geographical area as first-movers and may themselves be the earliest innovation policy in their location. For example, first-mover federal innovation policy for nanotechnology arose in Japan (1981), the United States (1985), the United Kingdom (1987), and China and Canada (1990). Later-stage nanotechnology policy arose in Iran (2003) and India (2007). While these are the years of the first introduction of national nanotechnology initiatives in each of the countries, those in Iran and India were much different than those established during the earliest years of nanotechnology emergence.

Next, we must define the first-mover advantage in terms of innovation policy outcomes. As discussed, the goals of innovation policy are increased innovative output (along with economic stability or growth). Therefore, first-mover innovation policy advantages would be those factors that improve the policy's ability to increase innovation and economic stability or growth. These goals may be in reference to other cities, regions, clusters, states, nations, or the prior performance of the policy's jurisdiction itself. It is important to note the frame of reference appropriate for the innovation policy at hand.

A. Advantages of being a first-mover innovation policy

First-mover advantages for a firm are technological leadership, asset preemption, and heightened buyer switching costs. Using these as guide lines, the next section explores the application of these advantages to innovation policy. Then, additional first-mover innovation policy advantages are explored.

As with firms, first-mover innovation policy may benefit from technology leadership by being on the cutting edge. By supporting such early stage innovation, these initiatives influence the trajectory of a nascent technology and its potential diffusion. Since first-mover innovation policy tends to be broad, they benefit in allowing for many trajectories of technology growth. Too narrow a focus could result in myopic innovation development that is not advantageous in the long-run. Also, first-mover innovation policy can also help shape the legal and regulatory environment and guide the development of follow-on initiatives.

Asset preemption also benefits first-mover innovation policy by allowing the geographic region under the policy's jurisdiction to attract and retain resources. For instance, during the earliest days of innovation on a nascent technology, those conducting research and development in the area will be attracted to locations supportive of this activity. At this point, there will be little competition since few areas are committing resources. Similarly, areas that initiate early policy to attract and maintain innovation attract firms and organizations to the area related to the innovation of interest. Also, this reduces the likelihood that firms would move once new innovation policies are enacted.

Additional benefits are available for first-mover innovation policy. Schumpeter [13] argued that new technologies provide opportunities for the appropriation of entrepreneurial profit, or surplus over costs. The Schumpeterian perspective suggests that R&D investment (such as innovation policy) increases localized spill-overs which will lead to regional disparities over time due to the compounding effects of early returns [4, 14, 15]. As such, regions implementing first-mover innovation policy benefit from increased long-term growth. First-mover innovation policies are also advantageous since they help the location build a reputation for supporting early stage technology.

B. Disadvantages of being a first-mover innovation policy

First-mover disadvantage for a firm are free-ridership, technology uncertainty resolution, enabling new entrants, and incumbent inertia. These exist for first-mover innovation policy as well. For instance, later policy has the advantage of building on the foundation that first-movers created. The earliest innovation policies must build an infrastructure for further innovation development. For example, first-mover innovation policies often must educate constituents and participants. These initiatives serve to educate both those involved in the innovation and the public. Later policy follows on to this work and can build from the work done by others. Especially important for later-stage policies is the legitimacy that first-movers lack. These later policies also benefit from the learning that took place during the first-mover's efforts.

Early innovation policy is also at a disadvantage due to the inherent uncertainty surrounding nascent technologies. This uncertainty taxes first-mover policies to resolve the fundamental aspects of technology and innovation development. Later-stage policies can be more focused and targeted in their resource distribution. As such, first-mover innovation policy may enable the creation of new policies that would otherwise not been possible.

First-mover innovation policy can also suffer from incumbent inertia as resource become committed and routines are institutionalized. Also, since first-mover innovation policy tends to be broad based, these initiatives cannot focus their resource allocation. This can lead to missed opportunities.

Additional disadvantages for first-mover innovation policy include fewer funding sources. Since first-movers support technologies that lack legitimacy and infrastructure, it is often difficult to gather resources. Since R&D in nascent technologies is usually more expensive than that of mature

areas, the funding that is generated by these policies is stretched. In contrast, once a technology has been established, later-stage initiatives may lack novelty and may be competing against a larger number of mature technology innovation policies.

IV. DISCUSSION AND CONCLUSIONS

Innovation policy is an important component of the public policy mix. While there are several advantages and disadvantages to establishing innovation policy before others, this may not be feasible in some areas. Therefore, it is important to note that first-mover and later-stage innovation policy need not compete with one another. Often these initiatives can work synergistically to build a stronger innovation system on the whole. By understanding the advantages and disadvantages associated with policy timing, policy makers can better integrate initiatives into the holistic planning for their constituents.

Other conditions must be considered when examining the order of entry in innovation policy such as the type of innovation policy being enacted and its scope of influence. For example, S&T initiatives gain a first-mover advantage from preempting academic resources while economic initiatives gain from preempting corporate resources. Benefits gained by first-mover advantage is specific to the level at which the policy is implemented. For instance, national innovation initiatives gain a first-mover advantage compared to other technologies. Local and state level innovation initiatives gain a first-mover advantage from clustering resources.

This work contributes to innovation policy research by applying the first-mover perspective to explore policy dynamics and timing. Using this lens, policy makers can enhance their initiatives implementation and outcomes. Planning for these initiatives should take into account the temporal dynamics of such policies and attempt to mitigate the disadvantages at each stage. By integrating this perspective into policy planning, both the resources necessary for and the potential outcomes can be optimized.

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